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Determining the Mean Level* Discharges of Water in any Line of
Direction of Small Rivers

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DETERMINING THE MEAN LEVEL * DISCHARGES OF WATER IN ANY LINE OF DIRECTION OF SMALL RIVERS

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(Submitted by Academician A. I. Nekrasov 23 January 1950)

To determine the mean level * discharges of small rivers (1) in the absence or inadequacy of hydrometric data, N. A. Velikanov proposed a solution based on the application of the methods of 3-dimensional interpolation and hydrological analogy, taking the water genesis into account, which, ^{according to} ~~as~~ L. L. Lichkov (2), is determined by the geological structure of a locality. The mechanical application of these methods, in the form of isohyetal charts representing the modulus of the annual water run-off, does not give any satisfactory results (3), since the analogy was established without first ascertaining the homogeneity of the water genesis, and the interpolation was made without due investigation of the community of physico-geographical conditions.

It is known that stable mean level discharges are ~~conditioned~~ ^{determined} by underground-fed waters. Many methods were proposed, therefore, for the determination ~~of the value~~ of the underground feed.

Hydrologically speaking, underground feeding is determined by ^{distinguishing} ~~the separation~~ in the hydrograph, the stable portion ^{according to} minimum discharge ~~value~~, and the variable portion ~~the~~ ^{the difference} between the high stable discharge ~~value~~ and minimum discharge ~~value~~, after cutting off the rain floods ~~values~~. However, this method does not clarify the distribution of underground feeding in a river system, and does not discover the ^{causes and effects} ~~causality and stipulated interdependence~~ of this phenomenon. ^{Moreover,} ~~the~~ minimum discharge ~~value~~, according to this

(Note: * The word "level" as used here and in the text stands for the special technical phrase "mean level of water in a river or lake".)

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method, is determined from ^{the given} ~~curve~~ equation $Q = \varphi(H)$, with an error up to 100 - 300 per cent, due to permanent deformations in the river bed, ~~unsteady operation~~ ^{operation} of ~~water mills and hydro-electric~~ ^{power plants} ~~stations~~, sharp temperature drop (in the winter), evaporation (in the summer). However, ~~even~~ ^{over} a perennial period of observations, this method does not always ~~characterize~~ ^{correctly} ~~values of~~ ^{values of} underground ~~water~~ ^{superficial} feeding of the ~~river~~ ^{beach}. For instance (See Figure 1), in the Ik River, the summer ~~discharge~~ ^{of water} may be diminished toward the estuary on account of transpiration from the bottomland ~~quartz~~.

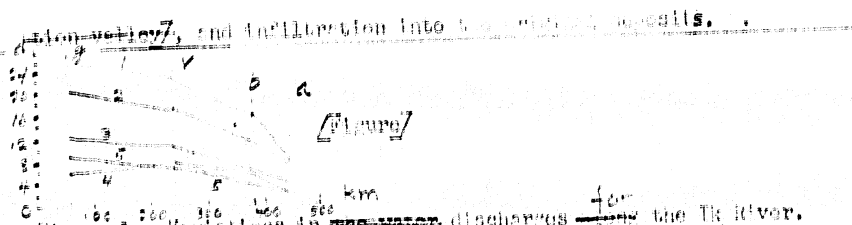


Figure 1. Variations in ~~river~~ ^{for} discharges ~~for~~ the Ik River.

1 - ~~measured~~ ^{measured} in 1960 by the hydrological expedition of the Kazan' Affiliate, Academy of Sciences USSR. 2 - Mean perennial for August. 3 - Mean perennial for January. 4 - Minimum monthly mean for the summer. 5 - Minimum monthly mean for the winter. a - Observation point Kulabay; b - observation point Apsalyanovo; v - observation point Nagaybak; g - observation point Podgornyye Baylyary; d - estuary.

~~more correct value for~~ Underground feeding can be determined ^{more correctly} by the F. A. Makarenko ⁽⁴⁾ and B. I. Kudelin ⁽⁵⁾ methods, which require detailed hydrogeological investigations. These methods cannot be applied to the numerous small rivers, since the ^{relation} ~~bond~~ between the river waters and the underground waters is diverse and cannot be established by a few supporting sources or typical lines of direction.

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When it becomes necessary to obtain data for numerous lines of direction of any small river, the magnitude and distribution of underground feeding along the river system can be determined hydro-metrically, with ~~sufficient~~ ^{sufficient} simplicity and ~~precision~~ ^{accuracy}, by A. A. Trufanov's ⁽⁷⁾ method, as the difference ~~in~~ ⁱⁿ the discharges of ~~adjacent~~ ^{adjacent} lines of direction. The ~~equilibrium~~ ^{water-bearing} capacity of small rivers of stable ~~level~~ ^{level} is an objective index of underground feeding, and the study of the variations of ~~level~~ ^{level} discharges ~~along~~ ^{along} the ~~course~~ ^{length} of ~~the~~ ^{the} river, clarifies the part played by physico-geographical conditions in the formation of the ~~level~~ ^{level} discharge and the genesis of its waters. Investigations of rivers (8-10) consist ~~in~~ ⁱⁿ measuring ~~the~~ ^{the} great quantities of water discharged during the period of summer stable ~~level~~ ^{level} along the ~~course~~ ^{length} of the entire river net, and ~~in~~ ⁱⁿ ascertaining ~~the~~ ^{the} potential discharges based on the analysis of the physico-geographical factors. The effect of the latter cannot be established a priori, ~~nor~~ ^{can} hydrological zoning (11) ~~be~~ ^{can} be done merely on the basis of coincidence of individual geographical features (see Table 1), or territorial proximity of rivers. [Note: Table 1 is in the appendix.]

~~The~~ ^{The} changes in ~~the~~ ^{the} lithological composition and ~~the~~ ^{the} thickness of the stratigraphic horizons, the presence of a deluvial-alluvial ~~covering~~ ^{speluncan}, fissures, ~~gavern~~ ^{gavern} ~~formation~~ ^{formation} processes, and, particularly, ~~the~~ ^{create} tectonic structure, all ~~go into the evolution of~~ ^{create} the peculiar local conditions for the movement and drainage of underground waters, which ~~have~~ ^{have} a sharply pronounced effect on the mean ~~water~~ ^{water} level of small rivers (12).

~~Short-period~~ ^{Short-period} investigations of rivers (9) ~~merely ascertain~~ ^{give a picture of} (the

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aquiferous capacity of a river, ^{corresponding to} ~~in accordance with~~ the climatic conditions of a given year. Their results cannot be utilized for ^{purposes of} ~~computation~~ as typical mean values, since the stability of mean level ~~water~~ discharges, even for river basins lying within a single climatic zone, is not the same and ^{depends} ~~depends~~ upon a very complex combination of physico-geographical and, mainly, biological conditions (see Table 2).

Table 2. Modules of mean August ~~water~~ discharges for the period 1932-1946. (in liters per second from basin area of one square kilometer)

River and point of observation	High-water		Ratio of $\frac{P_1}{P_2}$ (between high-water and low-water years)
	Year	Year	
Kazanka, D. Derbyanski	2.72	1.37	2.1
Ik, Harynsak	3.06	0.47	6.3
Ik, Kulyay	2.20	0.70	3.1
Ish, Lake Lebedinnoye	3.65	0.69	4.5
Sviyaga, Vyrtpayevka	2.34	0.52	4.4
Sviyaga, Kurunduki	1.15	0.23	5.0

[Figure 7] [see page 7 for the figure]

Figure 2. Variation in ~~water~~ discharges for typical Ik River tributaries; 1 - Discharge measured during investigations in 1948; 2 - ^{Total influx} ~~Summer discharge of tributaries~~ during 1948; 3 - Probable mean-annual discharge; 4 - Probable mean-winter discharge; 5 - Basin area in square kilometers; 6 - the cover line P_2^{kaz} in ^{absolute} ~~absolute~~ markings. A - Rya River; B - Killya River; V - Dymka River.

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It is not possible to investigate all rivers during all the years of their varying water cycles [high-water years and low-water years], in order to ascertain the mean ~~water~~ discharges along their course. Investigations have shown that to accomplish the above it is ~~only necessary~~ ^{and sufficient take} ~~to accomplish a single~~ ^{single} hydrological "photograph" of the mean ~~water~~ level. To ~~obtain~~ ^{obtain} the probable mean ~~water~~ ^{summer} and mean winter ~~water~~ ^{of water} discharges, it is necessary to subject the results of ~~short-time~~ ^{short-time} hydrological investigations to a hydrogeological analysis, for the ~~purpose of clarifying~~ ^{purpose of clarifying} ~~the~~ ^{possible variations in} ~~the~~ ^{discharges} ~~under~~ ^{under} ~~the~~ ^{climatic conditions, and} ~~the~~ ^{climatic conditions for} ~~the future~~ ^{the future}. The correctness of ~~the~~ ^{assumptions and computations along} ~~the~~ ^{length} ~~of the river is~~ ^{controlled by} ~~the~~ ^{indices} ~~the~~ ^{hydro-meteorological service} ~~water mills and hydro-electric power plants, and by comparison with the~~ ^{for} ~~results from the~~ ^{existing} ~~base~~ ^{base} ~~line of direction, of the~~ ^{line of direction, of the} ~~hydrological service.~~ ^{hydrological service.} In the absence of a line of direction based on personal observations of the river under study, the method of hydrological analogy is applied.

This method was used for determining the mean August and January ~~water~~ ^{length} discharges along the ~~length~~ of the following river systems: Ik, Oviyaga, Sheshma, Zay, and others (See Figure 2).

The Iya River lies in a ~~trough~~ ^{trough}-like tectonic depression. Considerable and conformable declivities on the terrestrial surface and in subterranean relief are conducive to the rapid run-off of surface and underground waters, particularly since the river system is cutting through the strata of sandstone (P_2 ^{Kaz. bel}) having ~~variable~~ ^{variable} aquiferous horizons. The stability of ~~water~~ ^{magnitude} discharges in ~~time~~ ^{time} is insignificant. The ~~reduction~~ ^{reduction} of the reduction

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in measured ~~the of the water~~ discharges ~~based~~ is based on the discharges of previous years and the ^{work} ~~performance~~ of water mills.

The Illiya river cuts through geological formations ^{which are devoid of} ~~which are~~ aquiferous horizons, $(P_{kz} + P_{kz} / 2)$. The discharge of the river system is ~~shape~~ ^{at} the headwaters of the rivers and its tributaries from the upper horizons (P_{tat}) . In consequence of the lithological variety of depositions, there are variations in the modulus of discharge; ~~but~~ ^{of} the stratifications ~~favorable~~ ^{shallow dip} a high degree of regularity of underground-fed waters and stability of water discharge is ~~common~~ ^{of} ~~the~~ ^{the}. The effect of the stratified complex of ~~clastic~~ and alluvial deposits accounts for the ^{decreased} ~~disturbance~~ in the discharge in the river-bed of the Illiya river, as compared with the discharges of its tributaries.

Along the course of the Syr Darya River there are sections having zero, positive, or negative ^{of influx [tributaries]} ~~flow~~ ^{rise} due to the various dips in the rock formations, although the river basin ~~as a whole~~ is situated in stratigraphic horizons ^{similar to} ~~with~~ those of the Illiya river. Individual tributaries and river sections, having ^{considerable} ~~storage~~ ^{in comparison with that on the} underground water ~~in the~~ ^{in the} surface, with the ~~additional features~~ ^{constancy} ~~of the~~ ^{of the} water discharge. The diminution of the water discharge at the estuary is due to the ^{spontaneous} ~~effect~~ ^{(influence} of caverns) ~~formation~~ (13).

The application of ^{this procedure of} ~~these~~ ^{utilizing the factual data} insures the most ^{accurate} ~~correct~~ determination of the probable mean level discharges ~~counter~~ in any line of direction of a river system, ^{which} ~~is~~ ^{necessary} ~~is~~ ^{of great importance} under the existing conditions

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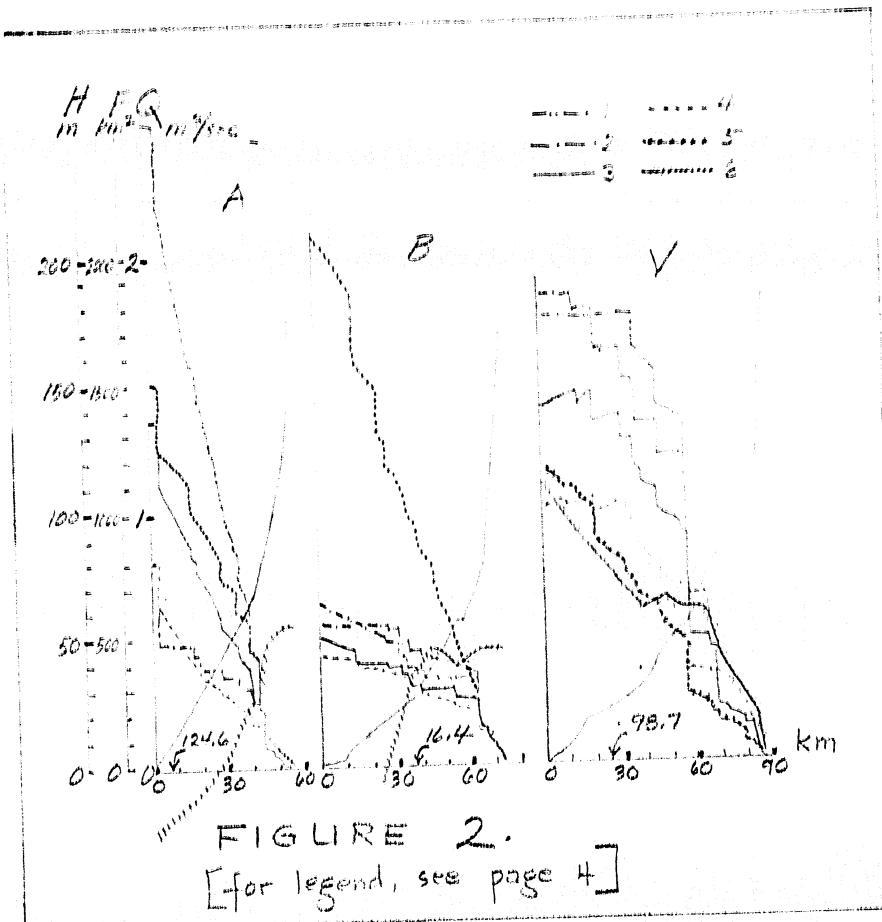
spread
of wide utilization of small rivers, precision in the constitution
of the rate of discharge of ~~the~~ water is determined by the degree
of knowledge gained through research and investigation of an area,
correctness and
and the completeness of the analysis of the prevailing physico-
geographical conditions.

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